Absolute Flux Measurements for IR Spectromicroscopy

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1. INTRODUCTION

Measurements of the effects of exposure to IR light at the spectromicroscope at beamline 1.4.3 has necessitated an estimate of the absolute flux levels in the IR optical bench and in the microscope. We calculated the IR flux levels from both a thermal source and the ALS, and compared them to measurements taken at the beamline. We find a self consistent picture which can be used to estimate the absolute exposure to cells and bacteria which are examined in the IR microscope.

2. EXPERIMENTAL

The thermal ("globar") source in the Nicolet 760 IR bench was measured with a disappearing filament style optical pyrometer to have a brightness temperature of ~1343K. This allowed us to calculate the "greybody power" emitted by the filament, using the emissivity of tungsten. We also measured the output of the thermal source with a Molectron PowerMax 500D with a 19 mm dia. PM10V1 detector. To measure ratios of light both before and after the bench and the microscope a more sensitive mid IR detector was needed so we employed a T3-09 9mm dia. energy detector, and a 200 Hz chopper. We also calculated the power of the synchrotron beam using the standard bending magnet formulae. The table below summarizes our results. Unless enumerated otherwise the numbers are in watts. Bold numbers are experimental data, others are calculations or estimates.

Greybody power	1.70E-04	**0.0479**	Synchrotron Power	3.73E-02
1 to 20 microns			1 to 20 microns	
1 mm^2, 0.0064 str, 1343 K			10 x 40 mr, 1.9 GeV, 4.81 m	
Real emitting area, mm^2	100	1	Beamline coupling loss	0.333
			20 out of 40 mr * 0.67 diamond	
Bench efficiency	0.372	0.372	Bench efficiency	0.372
Chopped Energy Detector			Chopped Energy Detector	
15.9/42.7			**15.9/42.7**	
Microscope Vignetting	0.1677	0.1677	Microscope Vignetting	1
Chopped Energy Detector				
1.5/15.9 * 12^2/9^2				
Microscope efficiency	0.225	0.225	Microscope efficiency	0.225
0.6/(1.5*12^2/9^2)			**0.6/(1.5*12^2/9^2)**	
Chopped Energy Detector			Chopped Energy Detector	
Power at sample	2.39E-04	6.72E-04	Power at Sample	1.04E-03
Greybody			Synchrotron	
Ratio of Synch/Greybody	**2**		Peak Power at Sample	5.20E-02
by MCT in Microscope			Synchrotron (*50)	
Ratio from this work	1.55		for 2ns/40ps	

3. RESULTS AND DISCUSSION

Starting from two calculations, and one measurement the table precedes from top to bottom from the two sources, thermal and synchrotron to the sample. At each step, there were many factors to consider. For example, the long depth of field of the synchrotron source means that all 40 horizontal mr of beam is not coupled into the microscope, and the synchrotron beam has a diamond window loss which the thermal beam does not. Moreover, the synchrotron beam has been carefully moved from the center of the optical axis so that it is not vignetted by the special coating in the center of the beam splitter in the optical bench, and the microscope optics have been adjusted to optimally transmit the synchrotron beam. This requires that the vignetting ratios for the two cases be different. We have done our best to honestly estimate the various factors, and measure them where feasible without significant disassembly of the beamline optics.

The final results are satisfying in that the ratio of the total synchrotron to thermal flux (1.55) that we get from our careful combination of theoretical and experimental measurements matches well within the error of our methods the ratio (2.0) we measure by comparing the two sources directly with the LN_2-cooled MCT detector in the microscope. The brightness advantage of the synchrotron (>100) is also verified. The overall error in the estimates is well represented by the factor of 2.8 between the two methods for estimating the power of the thermal source. The continuous power at the microscope integrated from 400 to 10000 cm^{-1} is estimated to be approximately 1 mW, and the peak power at the top of an ALS pulse to be fifty times (2 nsec / 40 psec) that, or 50 mW.

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